

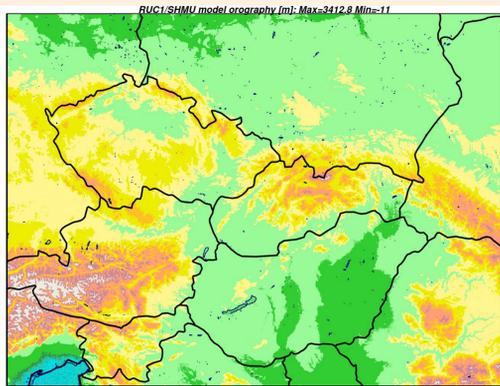
### Introduction

The original purpose of running a Rapid update cycle (abbreviated RUC1) at the Slovak Hydrometeorological Institute was to use it in the nowcasting and very short range forecasting period (min. +12h ahead). It was supposed that it could at least partially replace or supplement the existing INCA-SK nowcasting system (which forecast part is based mainly on extrapolation and blending with the ALADIN/SHMU model). The development of RUC1 started in 2021, with first regular runs since June 2022 (Belluš et al., 2022). In 2024, the RUC system is still considered as experimental (not a time-critical application). However, its forecasts are already available for the forecasters at SHMU and are evaluated in cases with severe weather. Certain RUC1 runs have been extended up to +24h for verification purposes and a version called ALA1 (run daily at 00 UTC) has been integrated up to +48h. From the beginning, RUC1 was based on the ALARO configuration and constructed to process the most recent available surface and upper-air data (short cut-off) via CANARI and 3DVAR configurations and with 1h cycling. The 1km horizontal resolution (same as for INCA-SK) provides more detailed fields of meteorological parameters in the mountain terrain of Slovakia compared to NWP models of coarser resolution run at SHMU (ALADIN/SHMU, ALA2E). Compared to INCA-SK, the forecasts of RUC1 contain not only basic surface parameters (as temperature and 10m wind) but also upper-air parameters (temperature, wind, geopotential, humidity) in various pressure levels, fields of simulated radar reflectivity, vertical velocity, vorticity, convective parameters and indices, etc. These enable better and more complex diagnostics of severe weather potential and of its background. In the future, it is planned to further improve both assimilation part (e.g. with new data inputs as GNSS/ZTD, radar data) and the model integration (to find optimal setting of physical parameterization, mainly with respect to deep convection). In case of intense convective events, RUC1 could sometimes provide more accurate forecasts than other SHMU models, mainly at the end of the nowcasting period (approximately around +6h range), whereas for the shorter periods (+2, +3h) it often showed a considerable spinup. Its reduction, as well as preparation of high-quality analyses close to observed data belong also to main objectives of further development.

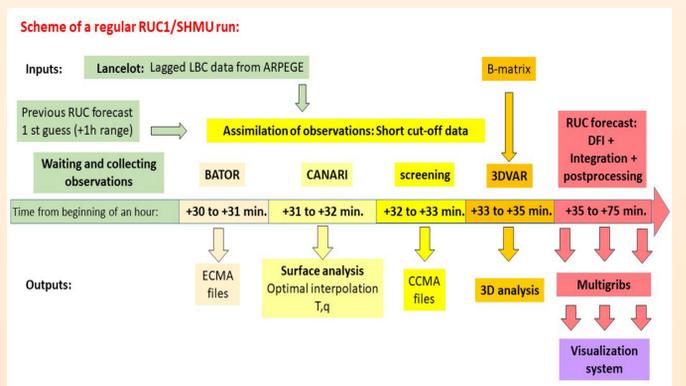
### Main characteristics

Version	Regular RUC1 (since 03/2024)	Test versions
Code	CY46T1b07	CY46T1b07+ (with CHMI modset)
Domain size	1024 x 768	As in regular RUC1
Vertical levels	87	As in regular RUC1
Time step	30s	30s, 45s
Forecast range and frequency	hourly, up to +12h, +24h at 00/06/12/18 UTC	+48h (ALA1)
Surface data assimilation	CANARI	CANARI with smoothing deep soil moisture (LISSEW4 experiment)
Upper air data assimilation	3D-Var	As in regular RUC1
Initialization	DFI	DFI, IAU
LBC frequency	1h (lagged ARPEGE data)	1h, 3h, lagged or not lagged
Coupling mode	SCC (space consistent)	TCC, SCC
Cycling	1h	1h, 3h (for LISSEW4 experiment)
Dynamics	NH dynamics, ICI, SLHD	As in regular RUC1
Physics	ALARO-1vB, use of 3MT	Tests with graupels, no 3MT, etc.

### Domain of computation



### Time management



### Assimilated observations

Surface: GTS data + AWS from OPLACE: SK+CZ+HU+AT+SI+PL+HR+RO data (mainly temperature, humidity)

Data for 3DVAR (OPLACE database):

TEMP (max. 4 times a day, only few stations), wind, temperature, humidity  
AMDAR (aircraft observations)

MODE-S EHS (high density aircraft observations), wind, temperature

MODE-S MRAR – direct measurements from aircrafts (wind, temperature)

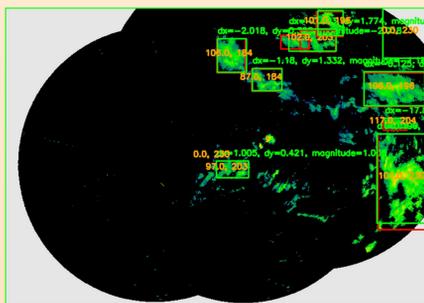
METEOSAT HRW – satellite derived wind data, atmospheric motion vectors (NWCSAF)

Planned:

GNSS (ZTD) – Global Navigation Satellite System zenith total delay (humidity)

Radar data (some preliminary tests done)

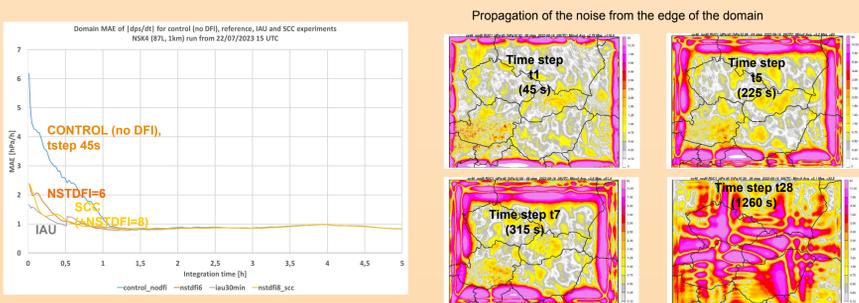
### Unveiling Key Features in Meteorological Domains



The identification of top 10 regions of interest (ROI) based on radar data helps to uncover the most significant meteorological features. We use Python libraries like opencv, scikit-learn. The RandomForestClassifier model automatically evaluates the importance of features, concerning their longevity and intensity. Time window is 15 minutes and radar step is 5 minutes. The goal is to determine important areas for data assimilation (DA) and to support object-oriented verification of forecasts. The method is currently in testing and works on PPI reflectivity. It will be applied on maximum reflectivity (both measured and simulated) in the future.

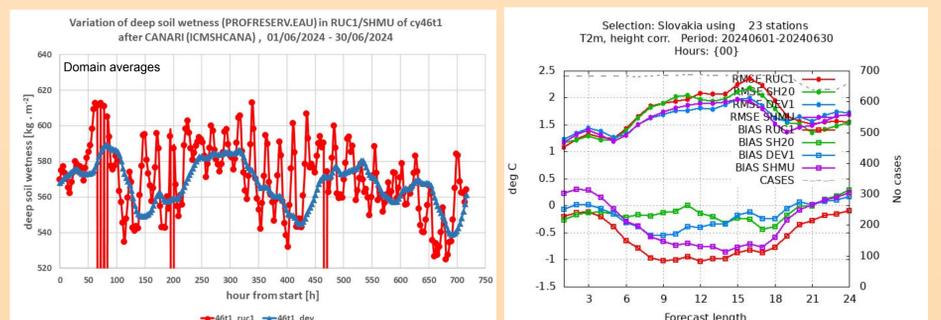
### Stability tests

Since 2022, crash due to numerical instability was not observed, although there are problems with spinup and oscillations, which are partially due to incompatibility of the assimilated data with the 1<sup>st</sup> guess or LBC data. These can be damped with use of digital filter, Incremental Analysis Update (IAU) or Space Consistent Coupling (SCC). We used the ECHKEVO application for the tests to visualize MAE of pressure tendency for the whole domain (see the graph on the left). We also visualized the spatial distribution of pressure tendencies, showing that the noise occurs mainly at the borders of the domain and it quickly propagates toward the centre of the domain (control experiment using TCC, see figures on the right).



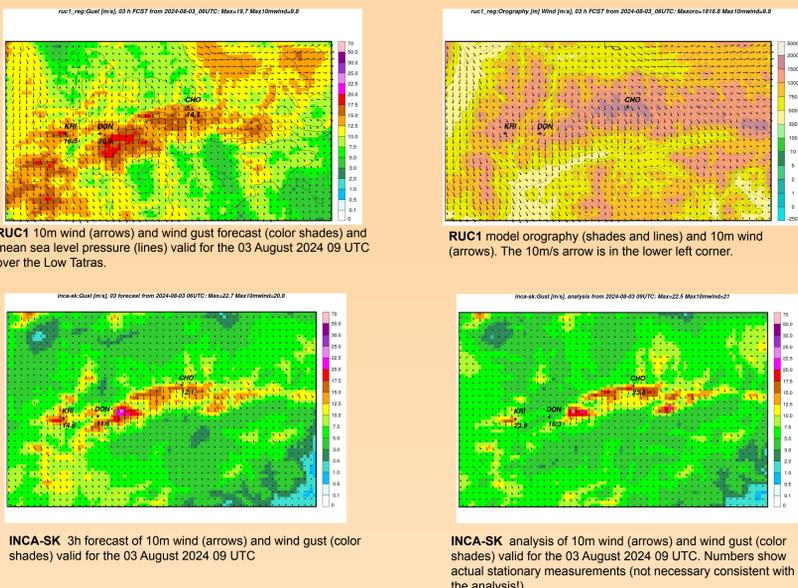
### Tests with smoothing the deep soil wetness (CANARI)

Experiments were provided to reduce the jumpiness in the deep soil water reservoir (PROFRESERVEAU), which can have large impact on the evolution of near surface temperature, thus, also on convection (Brožková et al., 2023). Smoothing of the deep soil water increments analysis was applied in the e701 configuration (CANARI) with aid of the LISSEW algorithm (LISSEW=T.). These experiments (denoted also LISSEW4), were also associated with 3h cycling (which is more commonly used as the 1h cycling in RUC1). Domain averages of the deep soil wetness indicated much smoother behavior in the experimental suite (dev) compared to regular RUC1 (ruc1). Experiment had also some positive impact on scores, except the first hours (which could be rather attributed to cycling difference).



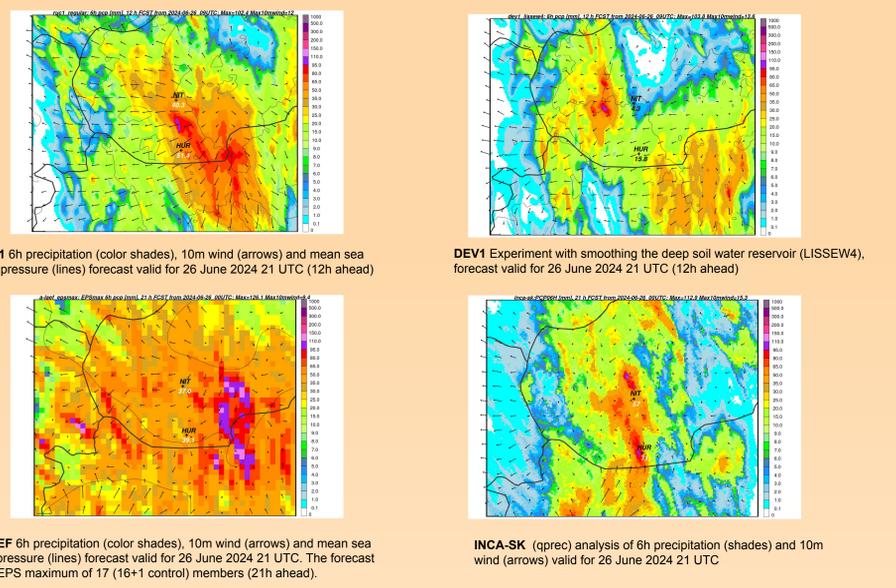
### Non-convective situations

RUC1/SHMU was evaluated in several kinds of weather situations. For strong, non-convective winds, we investigated the capabilities of the system to forecast local wind effects due to orography, lake effect, etc. We compared the forecasts with the operational ALADIN/SHMU and ALA2E models and with the nowcasts of the INCA-SK system (operating at 1 km resolution as well). On the figures below, one can see examples of RUC1 and INCA-SK 3h forecasts and corresponding analysis valid for 03 August 2024 09 UTC for the Low Tatra region (central part of Slovakia). The results indicate that both RUC1 and INCA underestimated the wind on the mountain crests (e.g. in the Chopok region, 2005m high). On the other hand, wind maxima can be found on the lee slopes of Low Tatras, probably due to mountain wave generation.



### Situations with deep convection

In the summer time of 2024 (June, July, August) the RUC1/SHMU successfully forecast several severe events related to deep convection (windstorms, flashfloods). In these kinds of situations, very short-range RUC1 forecasts sometimes outperformed forecasts of other NWP models (e.g. ALADIN/SHMU, A-LAEF). On 26 June 2024, several intense thunderstorms occurred over the southwest Slovakia, causing heavy precipitation and local downbursts as well. The regular RUC1 run at the time of the event was able to localize the maximum of the precipitation with high accuracy. However, experimental runs with different initial conditions (e.g. with smoothing the deep soil water reservoir and 3h cycling, LISSEW4 mentioned above) already predicted the maximum more westward. The forecast precipitation maximum in the hydrostatic, 4.8 km A-LAEF EPS system was also closed to observed amount but its position was situated about 40 km eastward from the real one.



### References

Belluš, M. et al., 2022: NWP related activities @SHMU, 44th EWGLAM and 29th SRNWP meetings, 26.9.-29.9.2022, Brussels, Belgium, poster  
Brožková, R., Bucánek, A., Mašek, J., Němec, D., Smolíkova, P., Trojčková, A., 2023: Numerical Weather Prediction activities at CHMI, 3rd ACCORD All Staff Workshop, 27-31 March 2023, Tallinn & hybrid, poster ([https://www.umr-cnrm.fr/accord/IMG/pdf/poster\\_cz\\_chmi\\_asw\\_2023.pdf](https://www.umr-cnrm.fr/accord/IMG/pdf/poster_cz_chmi_asw_2023.pdf))